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**Automatisering in bedrijf. Een empirisch-theoretisch onderzoek naar de effecten van automatisering op de functiestructuur van bedrijven**

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## Summary

The impact of automatization on job structures has been the subject of a broad discussion since the seventies. The origin of the discussion lies in the controversy between optimists and pessimists. Optimists point out the opportunities of new technology, such as new jobs, the demand for new skills and the improvement in labor conditions and career development of workers. Pessimists stress that automatization will lead to degradation of work and polarisation of job structures leading to negative career changes for less skilled workers. At the level of the organization, the debate was concentrated in particular around the finding that job structures in firms tend to be simultaneously upgraded and downgraded.

The aim of this study was to arrive at a general conclusion on (a) the impact and content of job structure changes after automatization in firms and (b) the most prominent determinants of these changes.

Changes in job structures can be defined as the result of changes in work (the content of jobs). Through automatization jobs can change in four ways:

- (1) Jobs are downgraded (the level of skills diminish);
- (2) Jobs are upgraded (the level of skills improve);
- (3) Jobs are created at a certain skill-level in the organization (*job gain*) and
- (4) Jobs are removed at a certain skill-level in the organization (*job loss*).

To mark out the resulting changes in the job structure of firms the explanandum of this study is limited to:

- (A) Changes in the mean skill level of firms, namely *downgrading and upgrading on job structures*) and
- (B) Changes in the division of skill levels in the firm namely *polarisation*.

Existing empirical research results can be divided into those supporting the degradation or polarisation hypothesis, those supporting the upgrading or convergence hypothesis and those supporting the hypothesis that automatization is not at all related to changes in job structure. For the greater part, this research is based on case study material. The constant contradiction between the outcomes of research is striking and persistent. Case studies on the effects of CNC-machines in metallurgic factories are well known because of their controversial outcomes (Bilderbeek e.a., 1985).

The studies which support the hypothesis that automatization does *not* affect the job structure of organizations have influenced the central question

of this study. Before focusing on the different changes in job structure, one could ask why structures change at all. Therefore, the central research question was refocused towards explaining the *chance* of polarisation and the *chance* of regradation in automated organizations. As a result, the contradiction of empirical support for the different effects of automatization still persists. The absence of standardized interorganizational research and the limited generality of case studies does not allow a preliminary answer to the question *why*, in apparently similar organizations, the effects of automatization differ.

Therefore a theory must be elaborated which can generate hypotheses which predict in which firms which changes in job structure are to be expected. The sociology of organisations is a diverse field of theoretical traditions. Different approaches have developed simultaneously, although some have been more popular in certain periods than others. Given our research question, we selected three different approaches in organisational sociology.

The first is the *technological determinism approach*. Based on the early work of Woodward and Touraine the idea behind this approach is that organizational structures vary with the level or state of technology. Studies by members of the Aston School empirically tested the relation between technology and type of organizational structure. This relation could in most cases not be confirmed. The technological deterministic approach was also criticized on theoretical grounds. One such contribution comes from Child. He introduced the idea of '*organizational choice*' which is used in theory and research today. In short, this concept states that in organizations, within certain technological constraints, managers always have a choice of alternatives to (re)organize work and organizational structures. The rise of this concept caused an important decline in the significance of technological determinism in organizational studies.

The *contingency approach* was selected as a second tradition in organizational studies. This approach has a strong tradition in the classic work of Burns & Stalker and Lawrence & Lorsch. The emphasis in this approach is placed on the influence of market conditions on organizational structures. The stability of the (market) environment makes some organizational structures more successful than others. With regard to technological change, this idea elaborated by Buitendam c.s.. They arrive at the hypothesis that the greater the stability of the market, the greater the change in polarisation due to automatization. Although attractive because of its clarity, a shortcoming of this hypothesis is the omission of organizations which do not operate on a market, such as public firms. More generally, a major criticism of the approach concerns the deterministic character of the idea. One could argue that the only difference between the contingency approach and technological determinism lies in the fact that on the one hand *only* technological conditions determine organizational structure, and on the other *only* features of market conditions. Moreover, contingency theory has seldom been worked out into concrete hypothesis which can be empirically tested.



As a third and recent tradition in the sociology of organisations, the *labor process approach* was discussed. This approach is based on the central ideas in Bravermans' writings on the control and division of labor. Marxists and 'verstehende' theories of power relations are combined in the concept of control to illuminate organizational structures. In the Netherlands many studies on the effects of automatization were done within this approach, for instance Doorewaards' study of power relations in the context of automatization in insurance companies. However, hypotheses on *how* the decision making process interferes with the relation between automatization and the changes in job structures have not been worked out, so that the empirical generality of the idea remains uncertain. The importance of this approach lies in the centralization of decision making as the 'interaction mechanism' through which *persons* in organizations decide on certain job adaptations.

Not only as a critical reaction, but also as an extension of these three approaches, a different theoretical approach was used to provide a more informative and complete answer to the central question of this study. More explicitly, choices of managers in organizations are assumed to be the core of the explanation of why jobs and, at aggregate level, job structures change after automatization. The conditions which influence the decisions of managers to alter jobs in certain ways are dealt with stepwise modelling of management behaviour. In all four steps are taken leading to several hypotheses which explain the change in jobs and job structures in terms of up- and downgrading and polarisation as described earlier.

In the *first step* the model starts with a situation of one manager in the firm who has to decide upon the degradation, regradation, creation or removal of jobs after automatization.

As a *first modification*, the manager is influenced by the technological features of the automation equipment. This influence is apparent in the costs that will arise when the skills of users of the automation equipment do not match the demand for skills. It is expected that managers will choose regradation or the creation of new jobs when automation equipment is complex or applied broadly in the firm. Under these conditions managers expect the costs of this 'skillgap' to be higher. On the other hand, it is to be expected that such job changes will be superfluous if equipment has already been in use for some time. In this situation, job changes such as downgrading and loss of jobs become more attractive to the manager. This led to the hypothesis that the chances of job loss and job degradation are higher when the equipment has been in use longer or is introduced in a situation where other similar equipment is already in use.

As a *second modification* to the first step of the model it is assumed that, besides internal goals such as controlling skill gaps, managers also have external goals such as the continuation of market production. In this way the idea is theoretically grounded that market situations are related to changes in organizations. The proposition is that stable market conditions stimulate the division of labor, since this is an efficient way of maximizing production.

The result of the division of labor in order to increase productivity is job creation on the one hand and job loss and degradation of work on the other. Therefore it is to be expected that under stable market conditions, the chances of job loss and downgrading and simultaneous job gain are higher. In addition, under unstable market conditions managers are eager to optimize the quality of their product to cope with the uncertainty of a changing environment. This leads to the hypothesis that regradation and creation of new jobs are to be expected because they are needed to support this flexibility through automatization.

To avoid the previously mentioned shortcoming of the contingency approach, the influence of market conditions was also elaborated for organizations outside the commercial environment, such as non-profit and public firms. The position of managers in non-commercial firms is different because their economic basis is dependent on budgets and government funds. In the absence of competition there is a constant demand for their products, so the only way managers can improve their position or status is to improve the quality of the services. Automatization to improve quality will only be useful in combination with upgrading of jobs, since the work remains relatively labour-intensive. Therefore a higher chance of job upgrading is expected in public than in private organizations.

In the *second step* towards constructing a model of management behaviour, the assumption that the manager is the *only* person in the firm who has an interest in and preferences concerning job changes after automatization is altered. This alteration is realized by picturing a decision making process in which the deliberations of the manager are influenced by three other actors.

First, employees as *users of the automation equipment* play a role in the decision making process. Their interest is especially in the upgrading of jobs, since this bears upon the content of their own work. Therefore, one can expect that in situations where users are involved in decision making the chance of job upgrading is larger.

Second, *automation experts* are relevant actors in the context of automatization in organizations. Experts have an interest in expanding specialized and advisory work in organizations, such as the implementation of new computer systems. With reference to job changes, the upgrading of jobs will benefit of the scope of their work in the organization. Therefore the hypothesis is that the involvement of automation experts in the decision making process heighten the chances of job upgrading and job creation accompanying automatization.

*Members of the works council* form collectively the third actor to be distinguished. In the Netherlands, firms with 35 fulltime employees or more are obliged to institute a works council. Members of this council legally have a right to interfere with important decisions such as changes of work and job structure. Since their interest is in all possible sorts of job changes, the expectation is that when the work council members are involved the chance of upgrading and job gain will be positively influenced, while the chance of downgrading and job loss will be negatively influenced.



In deriving these hypotheses, the underlying proposition is that the three actors *actually* influence the managers' deliberations when they are involved in the decision making. The *third step* in the elaborating the model consists of altering this assumption. The three extra hypotheses derived from this step are specifications of interaction effects. The influence of an actor's involvement (step two) is expected to be reinforced by the technological and market conditions (added from step one). This theoretical step was based on the idea of decision making as a process of exchange (Coleman, 1990, Stokman & van den Bos, 1989). Managers imaginarily exchange their policy position towards job changes for latent goods controlled by the three other actors.

Pursuing this insight, managers are dependent on the *users* of automation equipment where these employees control an efficient usage of and gain from the automatization. The first part of the adjusted proposition is the more complex, and the more recent the introduction of automation equipment in the firm, the more dependent managers will be on the cooperation and skills of the users and the more the decisions will be influenced by the interests of the users. The second part states that the influence of users will be reinforced under unstable markets and in non-commercial firms.

Automation *experts* are engaged by managers on the basis of their specialized skills. The dependency increases with the complexity, novelty and scope of automation in the firm. The proposition is that these equipment features demand greater knowledge and skills, especially in the fase of implementing the system. The influence of experts on managers' decision-making is therefore expected to be stronger when the equipment is complex, new and introduced broadly in the firm.

Members of the *works council*, the third actor, imaginarily exchange cooperation for influence over the managers' decisions concerning job adjustments. Managers have an interest in a cooperative works council. The adjusted proposition is: the broader the scope of automatization in the firm, the greater the chance of discussion with the works council on this matter and the more managers are influenced by them in their decision making.

With this hypothesis the decision model is complete, as far as the chance of job changes such as upgrading, downgrading, and gain and loss of jobs is concerned. The transformation to changes in job *structure* is the fourth and last step in the model. This transformation is a matter of applying rules of aggregation and definition.

The *first* sort of job structure change is the increase or decrease in the mean job level in the organisation. This depends on whether job upgrading or downgrading is occuring and whether job gain and job loss take place on average at a high or a low job level in the firm. In addition, such job changes can occur simultaneously, which can result in a net absence of change in the mean job level.

The *second* change in job structure is the division of job levels in the firm. We decided to concentrate on one sort of division: polarisation. It is a matter of definition when polarisation is said to be the result of job changes.

We have decided to use a broad definition, meaning that job upgrading *or* job gain at a high average level *or* job downgrading *or* job loss at a low average level will cause polarisation. In this way polarisation is defined as a probabilistic phenomenon than can occur to a greater or lesser extent as a result of job changes following automatization.

Finally, technology factors, market conditions and decision making situations are related to these three job structure changes. The model is now complete, predicting the conditions under which job structures are upgraded, downgraded or split up (polarisation) following automatization.

The complete model can be visualized in the following schema (figure S.1).

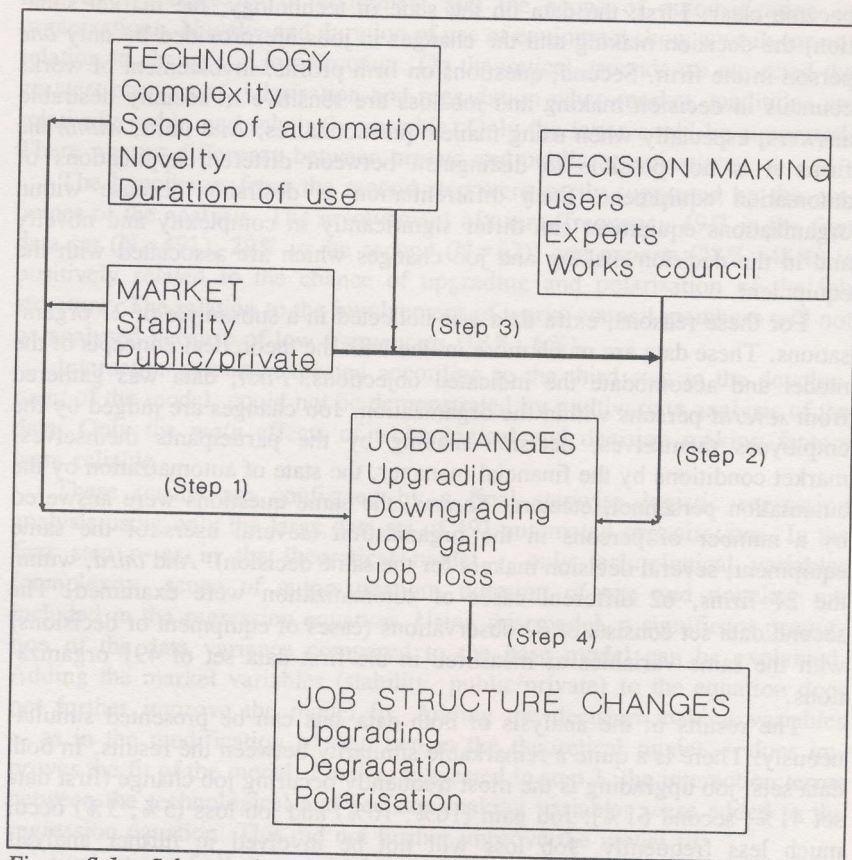


Figure S.1 Scheme of the explanatory model and its steps

In the model several insights concerning organisations are integrated. This integration was possible because of the starting assumptions of job change as the result of choice and choice as a deliberation by managers under different conditions. In this way hypotheses are founded by one consistent set of



theoretical premises and logically derived as empirically testable statements. Since the model is developed according to the method of decreasing abstraction (compare Lindenberg, 1983), it can be tested whether the theoretical elaboration of the model (in three steps) coincides with an improvement in the statistical fit of the model. This allows an extra evaluation and empirical test of the complete model.

The hypotheses and the model are empirically tested using two data sets.

The first data set consists of the results of a mailed questionnaire among 491 automated organizations in Limburg (a province in the south of the Netherlands) in 1986. Using these data it was possible to operationalize and measure the theoretical concepts, but at the same time several objections became clear. First, the data on the state of technology, the market situation, the decision making and the changes in jobs are provided by only *one* person in the firm. Second, questions on firm profits, involvement of works councils in decision making and job loss are sensitive to socially desirable answers, especially when using mailed questionnaires. And third, *within* the firms it is not possible to distinguish between different applications of automation equipment. Such differentiation is desirable because within organizations equipment can differ significantly in complexity and novelty and in the decision making and job changes which are associated with the equipment.

For these reasons, extra data was collected in a subsample of 27 organisations. These data are much more in line with the theoretical concepts of the model and accomodate the indicated objections. *First*, data was gathered from *several* persons within the organization. Job changes are judged by the employees themselves, decision making by the participants themselves, market conditions by the financial manager, the state of automatization by the automation personnel, etcetera. *Second*, the same questions were answered by a number of persons in the organisation (several users of the same equipment, several decision makers for the same decision). And *third*, within the 27 firms, 62 different cases of automatization were examined. The second data set consists of 62 observations (cases of equipment or decisions) with the same variables as measured in the first data set of 491 organizations.

The results of the analysis of both data sets can be presented simultaneously. There is a quite a remarkable similarity between the results. In both data sets, job upgrading is the most frequently occurring job change (first data set 41%; second 61%). Job gain (16%; 10%) and job loss (5%; 3%) occur much less frequently. Job loss will not be involved in further analysis because of these low frequencies. Job downgrading cannot be distinguished from job upgrading in the first data set, but the more accurate data (N=62 cases) show that such change was hardly present. Regradation of the job structure (a net increase in average job level) occurred most frequently in both data sets (56%; 41%). Degradation of the job structure can be left out of further analysis (2%; 5%). Polarisation, the main subject of the political



discussion, can be observed in 38% of the 491 firms and in 20% of the automation cases. This can be considered a relatively low rate of occurrence, since the definition of polarisation is broad.

In testing the hypotheses and the model it must be noted that in the first data set  $N=491$  and in the second  $N=62$ . Therefore we use the first data set to test for significance and the second to analyse the direction, linearity and strength of the expected relations. We will summarize the results with regard to the changes in job structure. The hypotheses are first analysed using bivariate analysis.

Some of the hypotheses from the first step are supported by the data. The chance of upgrading and polarisation of the job structure are positively related to complexity of equipment and the scope of automatization in organizations. Novelty and duration of use of equipment show a weak, or no, relation to changes in job structure. On theoretical grounds we expected the greatest chances of polarisation and regradation when market conditions are relatively stable *and* relatively unstable. Only the latter could be supported. There was no difference between private and public organisations.

The hypotheses from the second step were partly supported by the outcomes of the analysis. The involvement of users (frequency 49% in the first data set ( $N=491$ ); 29% in the second ( $N=62$ )) and experts (28%; 48%) is positively related to the chance of upgrading and polarisation of the job structure. The relation to the involvement of works council members will not be analysed because of low frequencies (18%; 6%).

Interaction effects, expected according to the third step in the development of the model, could not be demonstrated by multivariate analysis of the data. Only the *main* effects of technological and decision making factors were reliable.

These results are confirmed by a final stepwise logistic regression analysis using only the large data set of 491 automated organisations. In the first step — as in the theoretical model — only technological variables (complexity, scope of automatization, duration of use and novelty) are included in the regression equation. Using this model, a significant proportion of the data variance compared to the base model can be explained. Adding the market variables (stability, public/private) to the equation does not further improve the model fit. Adding the decision making variables — as in the modification of step two in the theoretical model — does improves the fit of the model. Finally, suggested in step 3, the interaction terms between the technological and decision making variables were added to the regression equation. This did not further improve the model fit.

Evaluation of all the results leads to the first main conclusion that same consequences of automatization cannot be demonstrated empirically. Degradation of jobs and job structures such as with job loss occur with such low frequencies that it makes no sense to examine these phenomena in order to test the theoretical model and hypotheses. This conclusion is by supported by two data sets collected in two different ways.

The second main conclusion is that in general there is support for the model we developed to explain variations between organizations in the chances of job structure changes. The support for the model is in favour of the effect of technological constraints and the influence of decision making partners as conditions under which managers imaginarily compare the pros and cons of certain job changes. Since not *all* technological features and decision making factors are significantly related to job structure changes, it is worth reconsidering the theoretical construction of these hypotheses. A suggestion with regard to the absence of an effect of market conditions might be a more accurate specification of the environmental features (for instance the temporal financial situation of the firm instead of stability of the market level).

Other possible modifications lie in the assumptions of the model. One could consider for instance distinguishing different kinds of managers, since 'the manager' is treated here as *one* actor in the model. With regard to the decision making process one could also consider introducing interactions between the three different actors.